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沖田孝一 Koichi OKITA
高田真吾 Shingo TAKADA
菅唯志 Tadashi SUGA
門口智泰 Tomoyasu KADOGUCHI
森田憲輝 Noriteru MORITA
谷浦有史 Tomofumi TANIURA
堀内雅弘 Masahiro HORIUCHI
絹川真太郎 Shintaro KINUGAWA
筒井裕之 Hiroyuki TSUTSUI

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Koichi OKITA[1)]　Shingo TAKADA[2)]　Tadashi SUGA[3)]　Tomoyasu KADOGUCHI[2)]　Noriteru MORITA[4)]
Tomofumi TANIURA[5)]　Masahiro HORIUCHI[6)]　Shintaro KINUGAWA[2)]　Hiroyuki TSUTSUI[2)]

沖田孝一　高田真吾　菅　唯志　門口智泰　森田憲輝
谷浦有史　堀内雅弘　絹川真太郎　筒井裕之

キーワード：レジスタンス・トレーニング，筋肥大，血流制限

抄　録

近年，レジスタンス運動に血流制限を併用することで，低強度負荷にも関わらず，高強度負荷と同等の筋力増加・筋肥大が得られることが報告された。このトレーニング方法の効果は，血流制限の併用によって生じる骨格筋の代謝的負荷の増強に起因していると考えられている。この方法は，一般的に複数セットで構成され，血流制限は運動・休息期継続して施行されるが，血流制限の継続は血圧上昇や被験者の苦痛を伴う。これらの問題点は血流制限を運動期もしくは休息期のみに間欠的に行なうことで，軽減可能と考えられる。本研究では血流制限を併用した低強度レジスタンス運動中の，間欠的血流制限とそのタイミングが骨格筋内代謝的負荷に及ぼす影響を検討した。健常男性７名に右足関節底屈運動（毎分30回）を最大挙上重量（1 RM）の20%を用いて，１分間×３セット施行し（セット間休息各１分），骨格筋内代謝的負荷は磁気共鳴分光法を用いて測定した。運動条件は，血流制限なし，運動時もしくは休息期のみに間欠的に血流制限を実施した２条件と継続的に血流制限を実地した条件の計４条件とした。また追加実験として，休息期血流制限に30% 1 RMおよび40% 1 RMの負荷を用いた条件を施行した。間欠的血流制限における骨格筋内代謝的負荷の増強効果は軽度であり，継続的血流制限に及ばなかった。一方，運動時と休息時の血流制限には差はなかった。しかしながら，負荷量30% 1 RM以上に増加させることで継続的血流制限と同等のレベルまで増加することも明らかになり，さらに被験者の自覚的疲労度も小さい傾向が認められた。

１）Department of Sport Education, Hokusho University
２）Department of Cardiovascular Medicine, Hokkaido University Graduate School of Medicine
３）Ritsumeikan University
４）Department of Sport Education, Hokkaido University of Education, Iwamizawa
５）Graduate School of Lifelong Learning Support Systems, Hokusho University
６）Department of Physiology, Yamanashi Institute of Environmental Sciences

Ⅰ．Background and aims

In recent year it has been reported that increases in muscle size and strength equivalent to those with high intensity load can be achieved even with low intensity loads (20-40% of 1 repetition maximum, RM) using blood flow restriction (BFR) together with resistance training[1]. However, there is a possibility that continuous BFR will markedly increase blood pressure and induce the development of blood clots [2) 3)]. There are also reports showing a high rating of perceived exertion[4]. Therefore, the aims of this study were to investigate the efficacy and timing of intermittent BFR procedures during low-intensity resistance exercise.

Ⅱ．Overview

Previously, we showed that intramuscular metabolic stress, such as pH decrease, phosphocreatine depletion and Pi accumulation during resistance exercise were markedly enhanced by BFR[5) 6) 7) 8)] and also demonstrated that enhanced metabolic stress proportionally contributed to training effects, muscle hypertrophy and strength gain.

Ⅲ．Methods

Seven healthy men performed 3 sets of 1-min unilateral plantar flexion (30 repetitions) with 1-min intervals under 4 different conditions: low intensity resistance exercise (L, 20 % 1-RM) without BFR (L-noBFR), L with BFR during rest periods (L-reBFR), L with BFR during exercise periods (L-exBFR), and L with continuous BFR during both exercise and rest periods (L-conBFR). Based on the results of this experiment, additional moderate intensity resistance exercises (40% 1-RM) with intermittent BFR (M-reBFR and M-exBFR) were performed in four of the seven subjects. Intramuscular metabolic stress, defined as phosphocreatine depletion and intramuscular pH decrease, was evaluated by ^{31}P-magnetic resonance spectroscopy

Ⅳ．Results

Phosphocreatine depletion (Fig 2, left) and intramuscular pH decrease in L-conBFR were significantly greater than those in L-noBFR, L-reBFR and L-exBFR ($p<0.05$), while those changes in L-reBFR and L-exBFR were equal and tented to be greater

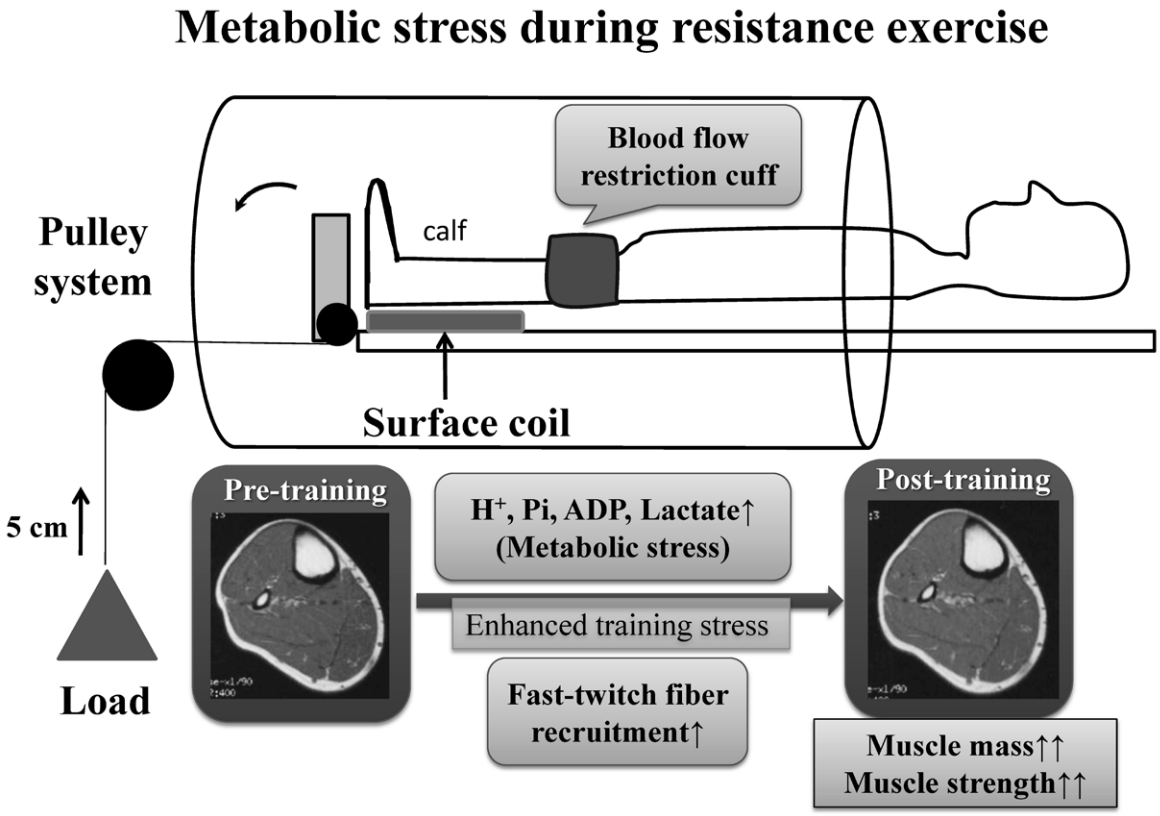

Fig 1. Overview of our previous studies.

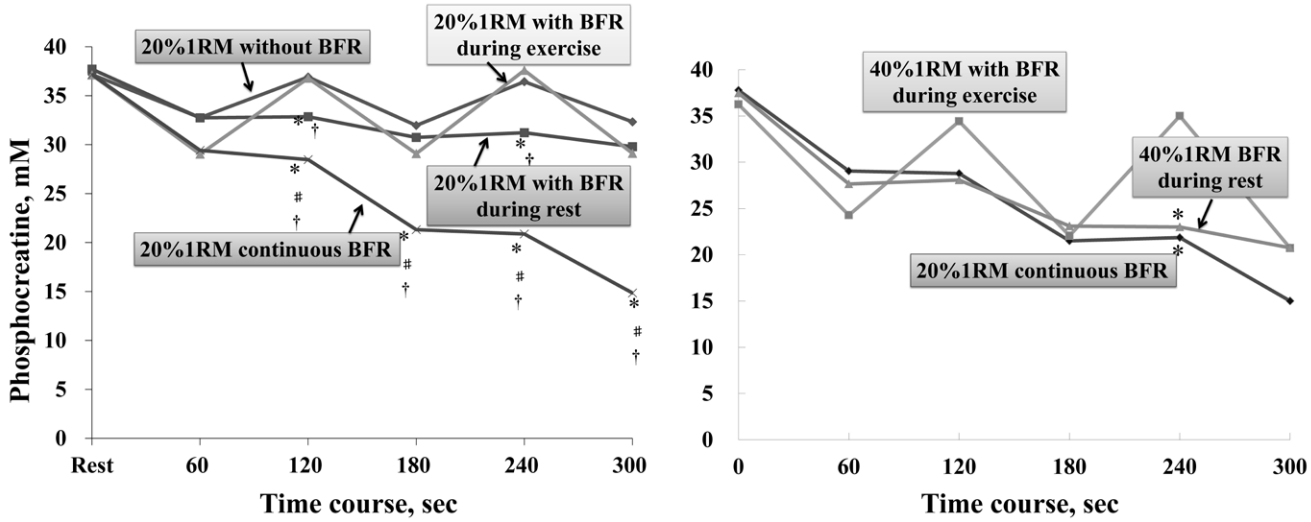

Fig 2. Phosphocreatine depletion during exercise.

than those in L-noBFR. By contrast, those changes in M-reBFR and M-exBFR were almost similar to those in L-conBFR (Fig 2, right). Subject's exertion after BFR during exercise was lower in L-reBFR and L-exBFR than in L-conBFR, and was tended to be lower in L-reBFR than in L-exBFR.

Ⅴ. Conclusion

In low intensity resistance exercise with BFR, continuous BFR can successfully increase muscular metabolic stress and might be the most effective method when the goal is improved muscle strength and size. However, an equivalent metabolic load can also be obtained with intermittent BFR exercises by increasing the exercise load. Regarding subject's exertion, moderate intensity with rest periods BFR could be useful method and applicable to resistance training.

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